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Terrestrial molluscs of the Province of Newfoundland and Labrador, Canada. Part 1: Boettgerillidae

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Abstract
The family Boettgerillidae, represented by the Eurasian slug *Boettgerilla pallens* Simroth, 1912, is first recorded for Newfoundland and Labrador, Canada—a range extension of almost exactly 5000 km within the Americas. Compiled, within an appendix, to provide a national perspective for the Newfoundland and Labrador record, are 13 previously unpublished *B. pallens* records from British Columbia, Canada. Incidentally recorded is the second eastern Canadian outdoor occurrence of the European slug *Deroceras invadens*. This paper is the first in a series that will treat all of the terrestrial molluscs of Newfoundland and Labrador.

Key words
Boettgerilla pallens; *Deroceras invadens*; distribution; first record; history of collecting; North America; British Columbia.

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Introduction

The terrestrial mollusc family Boettgerillidae Wiktor & Likharev, 1979 (Gastropoda: Stylommatophora) includes just 2 species: the Eurasian slugs *Boettgerilla compressa* Simroth, 1910 and *Boettgerilla pallens* Simroth, 1912 (= *Boettgerilla vermiformis* Wiktor, 1959). Both are notably slender taxa, commonly and appropriately referred to as "worm slugs". Both appear to have originated on the southwestern flank of the Caucasus Mountains, east of the Black Sea (Wiktor 1973, Reise et al. 2000).

Boettgerilla compressa remains restricted to a small region near its supposed centre of origin (Sysoev and Shileyko 2009).

However, sometime apparently within the last century, *B. pallens* expanded its range significantly, eventually occupying most of Europe, and parts of Asia (including Armenia, Tadzhikistan, and western Siberia [Chelyabinsk]) (Likharev and Wiktor 1980, Sysoev and Schileyko 2009). The "breakout" process, at least to the westward, clearly began sometime before 1949, when the species was first found in West Germany (Schmid 1966). That said, being a mostly subterranean species (Gunn 1992), *B. pallens* may well have been overlooked or misidentified in Europe for some time prior to being detected there (Turner et al. 1998, Reise et al. 2000, Balashov and Baidashnikov 2012). Whatever the case, it was not noted in Britain until 1972 (Colville et al. 1974).

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Figures 1–4. *Boettgerilla pallens* (NFM MO-2078). **1.** Lateral view, in extended, normal crawling position. **2.** A contracted specimen showing the dorsal keel. **3.** Semi-dorsal view, in extended, normal crawling position, showing the drawn-out and pointed posterior margin of the mantle, and the groove on the right side of the mantle running forward and backward from the top of the pneumostome, instead of forming a broad U-shape as in milacids. **4.** Showing the characteristic pneumostome area. Photographs by John E. Maunder.

Boettgerilla pallens Simroth, 1912. Figures 1–4.

Boettgerilla pallens Simroth (1912: 55–58, pl. 3, fig. 50; pl. 8, fig. 32)—Wiktor (1961: 131–134, figs 6, 7); Wiktor (1989: 137–139, figs 171–175).

Boettgerilla vermiformis Wiktor (1959: 1–2, figs 1, 2)—Wiktor (1961: 131–134, figs 3–5).

During the process of reporting the first known occurrence of *B. pallens* in the Americas, from the southern end of Vancouver Island, British Columbia, western Canada, Reise et al. (2000: 313) attempted to "draw worker's attention to the possibility of this species occurring in their own neighborhood in the near future, if not already", and suggested that "workers in other continents should realise that it is a potential colonist".

Indeed, elsewhere in the Americas, the species has now been found at: 3 localities in the vicinity of Bogotá, Colombia in 2000 (Hausdorf 2002); 2 localities in south-central Mexico in 2004 and 2014 (Araiza-Gómez et al. 2016); and 1 locality near San Mateo, California, USA in 2013 (Mc Donnell et al. 2014).

In Europe, *B. pallens* is still being reported from new areas (e.g., the Ukraine and Bulgaria—Balashov and Baidashnikov 2012, Dedov et al. 2015), although it remains unreported from all but the very north of the Iberian and Italian peninsulas (Borredà et al. 2010, Hallgass and Vannozzi 2010). As well, it has recently been found in the Canary Islands (Margry 2014).

Boettgerilla pallens is adapted for moving through earthworm burrows and other narrow soil spaces (Shikov 2007). Observations using a rhizotron found that individuals normally occur at depths of 2–20 cm, to a maximum of approximately 60 cm (Gunn 1992). The same rhizotron study found, further, that individuals were active underground during the day, when they ate mainly earthworm faeces, detritus, and soil. Several studies have reported that they will also eat other items, including carrion and roots (see review in Reise et al. 2000). Shikov (2007) observed that individual *B. pallens* appeared at the surface at night, where they preyed upon medium-sized snails. The species occurs in a wide range of habitats, including gardens and greenhouses (Plate 1965, De Wilde et al. 1983), but it is not known to be an agricultural or horticultural pest (Reise et al. 2000, Hausdorf 2002), although Moolenbeek (2002) described damage to "dozens of potatoes" [translated from Dutch] in his garden in The Netherlands.

Methods

On 14 October 2015, JEM collected 4 specimens of *B. pallens* in the city of St. John's, on the Island of Newfoundland, in eastern Canada; more specifically, from a sheltered, wooded slope in a mature urban environment, between Empire Avenue and Kelly's Brook ball field, just above a short unburied section of a brook of the same name (47.5731° N, 052.7112° W).

The 4 specimens were found under an approximately 25 cm diameter rock on damp bare earth, in a closed-canopy thicket of deciduous trees composed mostly of exotic maples (*Acer platanoides* L. and *Acer pseudoplatanus* L.) (Sapindaceae), with some scattered examples of a native serviceberry (*Amelanchier* sp.) (Rosaceae), and a dense, mid-to-late summer, understory of Wild Chervil (*Anthriscus sylvestris* (L.) Hoffm.) (Apiaceae) (Fig. 5).

This collection constitutes the first record of *B. pallens* for the Canadian province of Newfoundland and Labrador, as well as for eastern North America north of Mexico. Further, it constitutes a range extension of

Figure 5. Habitat of the Newfoundland locality of *Boettgerilla pallens*. Photo by John E. Maunder.

almost exactly 5000 km within the Americas (Fig. 6). All 4 specimens were deposited in the mollusc collections of The Rooms Provincial Museum (Newfoundland and Labrador) (NFM MO-2078).

In order to place the new Newfoundland record in a better national perspective, we have compiled (in the Appendix) all other known records of *B. pallens* for Canada. All are from British Columbia, including 4 completely new records by JMCH and HR (with others) documented herein, 4 published records in 2 papers (Reise et al. 2000, Neckheim 2014), and 9 records appearing in 7 unpublished technical reports (Ovaska and Sopuck 2002, 2004, 2005, 2008, Ovaska et al. 2016, Sopuck and Ovaska 2016a, 2016b, Kristiina Ovaska pers. comm. 2017). Given these 17 British Columbia records, and given their coherent, evenly spread distribution pattern, on both sides of the Strait of Georgia (Fig. 6), it is safe to conclude that the species is now well established in coastal, southwestern British Columbia.

While most of the localities recorded for the Americas are situated in rather natural-looking habitat outside of gardens, 2 of the British Columbia records (southeast of Duncan, and Surrey) and the California record are from garden centres, and 1 other British Columbia record (Stanley Park) is from a large park with significant horticultural plantings. These 4 records suggest one obvious mode of dispersal within North America.

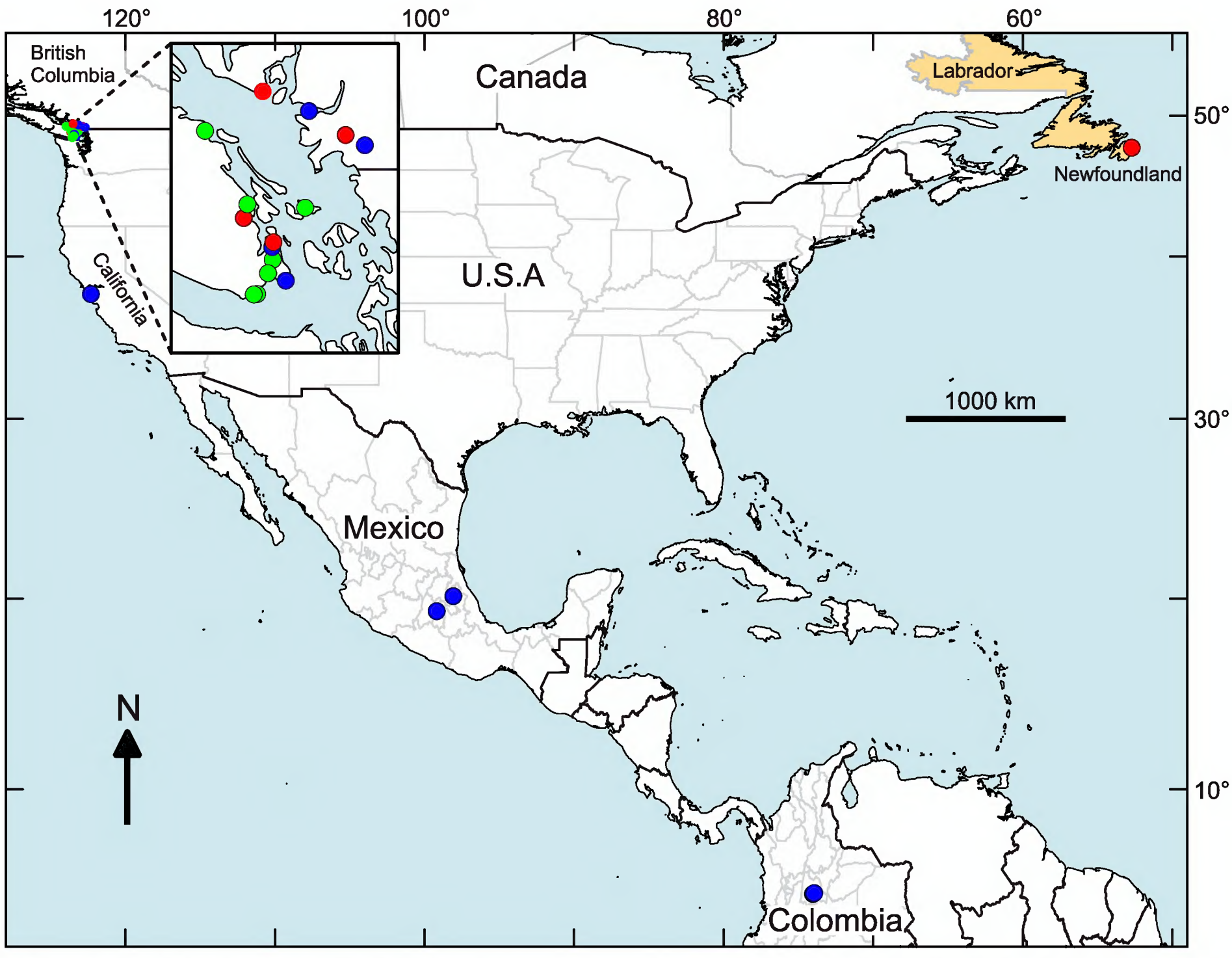

Figure 6. Known distribution of *Boettgerilla pallens* in the Americas. Red dots (St. John's, Newfoundland and Labrador (at right) and the Greater Vancouver/southern Vancouver Island area, British Columbia (at upper left, and in insert)) denote the 5 new collections made by the authors of this paper. Green dots denote previously unpublished records from technical reports. Blue dots denote cited literature records. The area of the insert is 132 × 180 km. For supporting details, see the main text and the Appendix. Map created in QGIS (QGIS Development Team 2017).

Results

The initial identification of the Newfoundland specimens was straightforward, given the unusual worm-like form of the animals while crawling (Fig. 1) (Rowson et al. 2014). Unlike in milacid slugs (which share a prominent keel running from mantle to tail; see Fig. 2), the rear of the mantle was elongated and pointed (Fig. 3), and the groove on the right side of the mantle ran only forward and backward from the top of the pneumostome (Fig. 3), instead of forming a broad U-shape, with the free-wings of the "U" pointing rearward (Wiktor 1961, Wiktor 1973). The colour of the 22–24 mm long animals (measured in extended, normal crawling position; Fig. 1) was an unspeckled grey (unlike juvenile animals, which are white—Wiktor 1961, Wiktor 1973). An enlargement of the characteristic pneumostome area is shown in Figure 4. The only other species of *Boettgerilla*, *B. compressa*, is not known to occur outside of a very restricted region of the Caucasus Mountains (Sysoev and Shileyko 2009). Its brownish colour is noticeably different from that of *B. pallens* (Sysoev and Shileyko 2009; compare also pl. 7, fig. 29 in Simroth 1910, with tab. 3, image 50 in Simroth 1912).

Twelve other species of terrestrial molluscs have been recorded at the Newfoundland *B. pallens* locality, all by JEM (Table 1).

Discussion

The Newfoundland occurrence of *B. pallens*, recorded herein, represents a significant range extension for this invasive Eurasian species, being roughly 3100 km west of the closest European (i.e., Irish) locality, and almost exactly 5000 km east of the closest British Columbia locality (Fig. 6). The closest Mexican locality is approximately 5100 km distant; the California locality is about 5600 km distant; and the closest Colombian locality is about 5200 km distant (Fig. 6). The new record of *B. pallens* from Newfoundland and Labrador suggests the possibility of additional occurrences in eastern North America.

Just how *B. pallens* reached the Island of Newfoundland remains unclear. The eastern edge of Newfoundland is the closest part of North America to Europe. For centuries (at least until the end of the Age of Sail) the harbour of St. John's, in particular, was the first North American port of call for the ships of a number of European countries. Many of these ships unloaded a great variety of European freight. Remarkably, even building stone, used primarily for fortifications, large places of worship, and merchant premises, was imported to the rocky shores of the Island. In addition, the merchant class imported many species of European vegetation, including trees, to plant in the gardens of their large houses and in local parks.

Many of the European ships, if "travelling light" to the westward (e.g., the outgoing European fishing fleets), regularly dumped ballast onto the shoreline at their destinations, in preparation for loading a paying cargo (Lindroth 1957). This ballast was often just a jumble of rocks, soil, pieces of old buildings, and whatever else was available, for free, at an earlier port-of-call. Secondarily, considerable trade in the opposite direction (i.e., eastward, often via Newfoundland) originated in north-eastern North American ports, particularly those of New York and Boston.

A striking result of all of this transportation of materials is that, today, the Island of Newfoundland, especially the general St. John's area, harbours a disproportionate number of introduced species of both flora (e.g., Cooper 1981) and fauna (e.g., Morris 1983), from Europe and beyond.

How long *B. pallens* has been present in Newfoundland is impossible to say because, as far as we know, no malacologist had searched the location of its discovery until 2015. Given that the first large merchant's houses in the general area were built as early as the 1840s (e.g., Bannerman House), it is quite possible that at least some introduced snail and slug populations were present there as far back as the middle of the 19th century. That said, it would appear that only during the last half-century or so did *B. pallens* become common enough in Western Europe to qualify as a likely colonist to Newfoundland.

In order to place the recent Newfoundland discovery of *B. pallens* in better perspective, and to demonstrate, through a brief historical account of search effort, that the species is almost certainly truly rare there, it seems useful to give a short account of the history of terrestrial mollusc collecting in the province of Newfoundland and Labrador.

The first serious collections of terrestrial molluscs on the Island of Newfoundland were made, somewhat incidentally, by Philadelphia botanist Bayard Long, who

Table 1. Terrestrial molluscs occurring with *Boettgerilla pallens* at the Newfoundland locality.

Family	Species
Agriolimacidae	*Deroceras invadens* Reise et al., 2011*
	Deroceras reticulatum (Müller, 1774)
Arionidae	*Arion distinctus* Mabille, 1868
	Arion hortensis Férussac, 1819
	Arion subfuscus s.s. (Draparnaud, 1805)
	Arion circumscriptus s.s. (Johnston, 1828)
	Arion fasciatus s.s. (Nilsson, 1823)
Cochlicopidae	*Cochlicopa lubrica* (Müller, 1774)
Discidae	*Discus rotundatus* (Müller, 1774)**
Helicidae	*Cepaea nemoralis* (Linnaeus, 1758)
Limacidae	*Lehmannia marginata* (Müller, 1774)
Oxychilidae	*Oxychilus cellarius* (Müller, 1774)

* On May 24, 2015, JEM collected *D. invadens* at the Newfoundland *Boettgerilla* locality. The genitalia of a dissected specimen (from NFM MO-2079) very closely matched examples illustrated in Reise et al. (2011), and in Forsyth (2014). This collection is significant, since it constitutes only the second outdoor record of *D. invadens* for eastern Canada. The first eastern Canada outdoor record of *D. invadens* (Forsyth 2014) was also collected from St. John's, from a location approximately 0.9 km south-southeast of the second one. Interestingly, repeated attempts by JEM to rediscover *D. invadens* at the first site have been unsuccessful, suggesting that the occurrence at that particular spot was ephemeral. Chichester and Getz (1969) reported *D. invadens* [as *D. caruanae*] from greenhouses in two cities in Quebec (Sherbrooke and Quebec City) in 1966. For additional Canadian records, see Hutchinson et al. (2014: 37).

**Forsyth et al. (2016).

accompanied the eminent Harvard University botanist Merritt Lyndon Fernald on several botanical expeditions within eastern North America, including 4 to the Island of Newfoundland, in 1924, 1925, 1926, and 1929 (Fernald 1926, 1933). Long's Newfoundland mollusc collections, made mostly from limestone areas on the west coast of the Island in 1924, 1925, and 1929, were deposited in the Academy of Natural Sciences of Philadelphia (now the Academy of Natural Sciences of Drexel University), USA, and were published on by E. G. Vanatta (1925, 1927, 1930).

The next serious collections of Newfoundland terrestrial molluscs were made by Stanley Truman Brooks, Curator of Molluscs, Carnegie Museum, Pittsburgh, Pennsylvania, USA, along with his wife Betty Watts Brooks, a botanist at the Pennsylvania College for Women, during 4 extended trips between 1934 and 1938 (Brooks 1936, Brooks and Brooks 1940). On the second trip (which B.W. Brooks did not participate in), collections were also made in southern Labrador. All collections from these trips were deposited in the Carnegie Museum.

In 1964, RGN began mollusc collecting (terrestrial, freshwater, and marine) in both Newfoundland and Labrador. He was joined in this endeavour, in 1983, by JEM. Together, they have amassed significant collections of both Newfoundland and Labrador molluscs, which are now held in The Rooms Provincial Museum (Newfoundland and Labrador) (NFM). However, because of the still extremely limited road and coastal boat network available in the sparsely populated region of Labrador (1 person/11 km^2), mollusc collecting there remains much more of a challenge, and thus much more limited, than it is on the Island of Newfoundland. The present paper is the first in a developing series that will ultimately treat all of the terrestrial mollusc species of Newfoundland and Labrador.

In the late 1960s, Chichester and Getz (1969) collected slugs on the west coast of the Island of Newfoundland. Additional intermittent collecting has been carried out in association with the National Museums of Canada (now the Canadian Museum of Nature), the Newfoundland and Labrador Wildlife Division, and the Department of Biology, Memorial University of Newfoundland (Goudie 1997, Moss 2004, Humber 2009, Moss and Hermanutz 2010, Humber and Hermanutz 2011). As well, some minor, occasional, opportunistic collecting has been conducted by both residents (e.g., Bateman and Burzynski 2008) and "travellers in the country" (e.g., Oughton 1940). Photography has also been employed as a primary tool (Maunder and Voitk 2010).

In addition, Beck (1837: 59) provided the first record of *Cepaea* [as *Helicogena*] *hortensis* (Müller, 1774) from Newfoundland; Clapp (1900) provided an additional record of the same species [as *Helix hortensis*]; Whiteaves (1904) reported the first record of *Arianta* [as *Helicigona*] *arbustorum* (Linnaeus, 1758); Walker (1916: 260–261) was the first to report *Novisuccinea* [as *Succinea*] *ovalis* (Say, 1817), *Discus whitneyi* [as *Pyramidula cronkhitei anthonyi*] (Newcomb, 1864) and *Deroceras reticulatum* [as *Agriolimax agrestis*]; Altena (1950: 16) gave an evaluation of *Lehmannia marginata* [as *Limax* (*Lehmannia*) *marginatus*] (Müller, 1774) from Newfoundland; Gerber (1996) described the new species *Vallonia terraenovae*; McAlpine et al. (2009) provided additional records of *A. arbustorum* from Newfoundland; Forsyth (2014) provided the first outdoors record of *Deroceras invadens* from eastern Canada; and Forsyth et al. (2016) reported additional Newfoundland records of *Discus rotundatus*.

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Authors' Contributions

JEM collected the Newfoundland material and took the photos. JMCH constructed the map from coordinates provided by JEM. JMCH and HR collected (with others) some of the newly-reported British Columbia material. JEM (primarily), RGN, JMCH and HR wrote the text.

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Appendix

Records of *Boettgerilla pallens* from western Canada

Since the initial findings of *B. pallens* on southern Vancouver Island, British Columbia, Canada, at Oak Bay (Victoria) and Central Saanich in 1998 (Reise et al. 2000), there have been 11 additional findings on the Island (2 of which are our own), and what we understand to be the first 4 findings of the species on the British Columbia mainland (2 of which are our own).

In order to place the new Newfoundland and Labrador, Canada, record in a better national perspective, we have here compiled all previously known Canadian records ($n = 17$):

Vancouver Island and nearby islands (records 1, 3 and 4 can be found on the Royal British Columbia Museum "E-Fauna BC" website at: http://linnet.geog.ubc.ca/efauna/Atlas/Atlas.aspx?sciname=Boettgerilla%20pallens):

[1] Oak Bay, near Victoria, 1998 (Reise et al. 2000), collections of the Royal British Columbia Museum (RBCM 998-00224-001), and collections of the Senckenberg Museum für Naturkunde Gorlitz, Germany (p5495) (examined by JMCH, HR).

[2] Central Saanich, 1998, (Reise et al. 2000), collections of the Royal British Columbia Museum (RBCM 002-00180-001), and collections of the Senckenberg Museum für Naturkunde Gorlitz, Germany (p5496) (examined by JMCH, HR).

[3] SE of Duncan, just SW of Cowichan Bay (48.7374° N, 123.6517° W), at a retail plant nursery at the junction of Highway 1 and Phipps Road, on and under plant pots, October 13, 2001, collected by R. Forsyth, T. Forsyth, HR and JMCH. Specimens deposited in the Royal British Columbia Museum (RBCM 003-00097-007) (examined by JMCH, HR).

[4] North Saanich Quarry Park (48.6128° N, 123.4156° W), October 12, 2001, collected by R. Forsyth, HR and JMCH. Specimens deposited in the Royal British Columbia Museum (RBCM 002-00180-001) (examined by JMCH, HR).

[5] Metchosin, near Mary Hill, coniferous, mature fir (*Abies*) (48.3409° N, 123.5415° W), March 29, 2002 (Ovaska and Sopuck 2002, Ovaska, pers. comm. January 2017). Photographed by Kristiina Ovaska (Biolinx Environmental Research Ltd, North Saanich, B.C.), 2 photos are available on the Royal British Columbia Museum "E-Fauna BC" website at http://linnet.geog.ubc.ca/efauna/photoGallery/gallery.aspx?specrep=0&latinName=Boettgerilla%20pallens. One of the 2 photographs is additionally available on the University of California (Berkeley) "CalPhotos" website (http://calphotos.berkeley.edu/cgi/img_query?enlarge=0000+0000+0105+0173).

[6] Metchosin, at Rocky Point (48.3387° N, 123.5673° W), aspen grove, wetland edge, June 3, 2004 (Ovaska and Sopuck 2004, Ovaska, pers. comm. January 2017).

[7] Lyall Creek, Saturna Island, off Vancouver Island (48.7928° N, 123.1661° W), moist mixed forest and riparian vegetation, October 5, 2004 (Ovaska and Sopuck 2005, Ovaska, pers. comm. January 2017).

[8] near NE end of Quamichan Lake, at Elkington Creek (48.8091° N, 123.6242° W), moist mixed forest, June 19, 2008 (Ovaska and Sopuck 2008, Ovaska, pers. comm. January 2017).

[9] Departure Bay, Beach Estate Park (49.1911° N,

123.9660° W), moist mixed forest, June 19, 2008 (Ovaska and Sopuck 2008, Ovaska, pers. comm. January 2017).

[10] Observatory Hill 1, West Saanich (48.5211° N, 123.4194° W), moist mixed forest in gully, April 17, 2015 (Ovaska et al. 2016; Ovaska, pers. comm. January 2017).

[11] Colwood (FFTA Creek) (48.4496° N, 123.4559° W), riparian alder (*Alnus*) along creek, October 16, 2015 (Sopuck and Ovaska 2016b; Ovaska, pers. comm. January 2017).

[12] Observatory Hill 2, West Saanich (48.5209° N, 123.4205° W), Douglas-fir (*Pseudotsuga menziesii*)/ Garry Oak (*Quercus garryana*) woodland, near buildings, November 9, 2015, (Ovaska et al. 2016, Ovaska, pers. comm. January 2017).

[13] Colwood (COL30) (48.4501° N, 123.4576° W), mixed riparian forest, along creek, February 9, 2016 (Sopuck and Ovaska 2016a; Ovaska, pers. comm. January 2017).

Mainland British Columbia:

[1] Surrey (within Greater Vancouver). HR discovered 2 specimens in the open part of a garden centre at King George Boulevard (Highway 99A) between 92 Avenue and 96 Avenue (49.1732° N, 122.8451° W) on September 29, 2004. This Greater Vancouver locality was 74 km NE by N of the closest of the 4 Vancouver Island localities then known by us (North Saanich Quarry Park), and on the opposite side of the Strait of Georgia, which is about 15 km wide here. Additional mollusc species, all found under flower pots, wooden planks and plastic sheets, were *Deroceras laeve*, *D. reticulatum*, *Limax maximus*, *Arion subfuscus* s.s., *Arion hortensis, Oxychilus draparnaudi and Cepaea* sp., all alien species. The *B. pallens* specimens collected were deposited in the collection of the Senckenberg Museum of Natural History, Görlitz, Germany (p20538) (examined by JMCH, HR). The non-specific mention in Grimm et al. ("2009") of the presence of *B. pallens* in the Vancouver area derives from this record. This was the first reported occurrence on the North American mainland.

[2 and 3] Neckheim (2014) discovered 2 additional British Columbia occurrences, at 2 sites within Greater Vancouver area, in 2010; 1 in a patch of native forest in suburban Surrey and 1 in Stanley Park near downtown Vancouver.

[4] Gibsons (WNW of Greater Vancouver). JMCH found 2 specimens about 120 m apart near the town centre on August 6, 2013. One was in woodchip mulch in a flower bed in the small park beside Gower Point Road (49.4000° N, 123.5078° W). The other was nearby, under a board between 2 small buildings at the end of suburban gardens (49.39908° N, 123.50740 W). Gibsons lies ca 29 WNW of Neckheim's Stanley Park locality, beyond the NW corner of the Greater Vancouver area; the journey from Greater Vancouver includes a 40-minute ferry trip. Additional mollusc species collected in the neighbourhood were *D. reticulatum*, *D. invadens*, *A. subfuscus* s.s., *Arion distinctus*, *Arion circumscriptus* agg., *Arion rufus*, *Cochlicopa lubrica*, *O. draparnaudi* and *Cepaea nemoralis*. The *B. pallens* specimens were deposited in the collection of the Senckenberg Museum of Natural History, Görlitz, Germany (p20548) (examined by JMCH, HR). This is the first reported occurrence on the Canadian mainland outside Greater Vancouver.